Louisiana State University
LSU Digital Commons

LSU Historical Dissertations and Theses | Graduate School

1957

The Differential Effects of Distributed Practice in Compound Trial-And-Error Learning.

Francis John Farese
Louisiana State University and Agricultural & Mechanical College

Follow this and additional works at: https://digitalcommons.lsu.edu/gradschool_disstheses

Recommended Citation
Farese, Francis John, "The Differential Effects of Distributed Practice in Compound Trial-And-Error Learning." (1957). *LSU Historical Dissertations and Theses*. 185.
https://digitalcommons.lsu.edu/gradschool_disstheses/185

This Dissertation is brought to you for free and open access by the Graduate School at LSU Digital Commons. It has been accepted for inclusion in LSU Historical Dissertations and Theses by an authorized administrator of LSU Digital Commons. For more information, please contact gradetd@lsu.edu.

THE DIFFERENTIAL EFFECTS OF DISTRIBUTED PRACTICE IN COMPOUND TRIAL-AND-ERROR LEARNING

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Psychology

by
Francis John Farese
B.S., Trinity University, 1951
M.A., Louisiana State University, 1955
January, 1957

ACKNOWLEDGEMENT

The writer wishes to express his indebtedness and gratitude to Dr. Robert Thompson for his guidance and helpful encouragement during the study. He further wishes to thank Drs. Berg, Bass, Levinger and Wade for assistance they rendered in technical critiques of this study. To Dr. Bernard M. Bass, he is thankful for financial aid for equipment necessary for this study. Dr. Clyde E. Noble suggested the study and made available the Human Learning Research Laboratory for conducting the study.

TABLE OF CONTENTS

	PAGE
TITLE PAGE	i
ACKNOWLEDGEMENT	ii
LIST OF TABLES	iv
LIST OF FIGURES	v
ABSTRACT	vi
INTRODUCTION	1
PROCEDURE	7
Apparatus	7
Task	11
Design	12
Subjects	13
RESULTS	14
DISCUSSION	26
SUMMARY	29
REFERENCES	31
APPENDIX	34
VITA	37

LIST OF TABLES

Number		Page
1	Analysis of Variance of Correct Responses Per Trial (1 to 10)	21
2	Analysis of Variance of Correct Responses for C10 for Trials 1 to 20	22
3	Analysis of Variance of Correct Responses Per Trial (1 to 20)	23
4	Frequency Distribution of Correct Responses (R_+) and Probability of Correct Responses (R_p) for C4 for 20 Trials	24
5	Frequency Distribution of Correct Responses (R_+) and Probability of Correct Responses (R_p) for C10 for 20 Trials	25

LIST OF FIGURES

Number		Page
1.	The Selective Mathometer with the Automatic Programmer and Data Collector	9
2.	Probability of Correct Response as a Function of Trials for C4 for Each of the Four Levels of Distribution of Practice	18
3.	Probability of Correct Response as a Function of Trials for C10 for Each of the Four Levels of Distribution of Practice	19
4.	Probability of Correct Response as a Function of Trials for C4 and C10	20

ABSTRACT

The subject of this research is primarily concerned with the differential effects of distribution of practice and task complexity in human trial-and-error learning. The secondary issue of this study is the demonstration of the feasibility and practicality of the use of automatic equipment for data collection and I. B. M. digital computers for data analysis for a psychological study.

The task presented to each of 240 subjects was one of paced, four-choice selective learning with serial reinforcement. Response availability was either four or ten with a task length of four. There were four levels of distributed practice, ranging from maximumly massed to relatively high distributed practice.

To stimuli presented automatically the subject's task was to acquire four distinctive S-R connections within 20 trials. The learning device was an automatic version of the Selective Mathometer, a multiple choice pushbutton learning device. Thirty subjects were assigned to each of the eight treatment combinations.

The empirical plots of probability of correct responses

as a function of practice yielded sigmoidal acquisition curves, satisfying a rationalized Gompertz growth curve.

The general conclusions of the study were: (a) varying the number of responses available was effective in varying task difficulty. (b) The main effect of distribution of practice was significant only for the more difficult task. (c) The interaction of distributed practice with task complexity was not significant. (d) The second-order interaction of task complexity by distributed practice by trials was significant. (e) A system of automatic equipment for data collection and digital computers for data analysis was demonstrated to be feasible and practical.

INTRODUCTION

One of the most general conclusions about the many factors influencing the rate of learning is that some form of positive distribution of practice produces faster learning than does massed practice. The range of conditions under which it holds is so wide that it has appeared to be a warranted conclusion.

As early as 1885 Ebbinghaus demonstrated the efficacy of distributed practice over massed practice. By 1915 there were six separate theories and twenty references concerning this distribution phenomenon (8). Since that time, the differential effects of distributed practice has been extensively studied in the area of human and animal maze learning, human verbal learning and human motor learning. The results indicated essentially the same general conclusion.

Many factors have been analyzed in an attempt to explain the efficacy of distributed practice in human subjects. One has been a consideration of overt or implicit <u>rehearsal</u> during the rest period in distributed practice. Sackett (16, 17) has shown that rehearsal is an effective facilitating condition in the case of maze habits. But that rehearsal is not a sufficient explanation has been established by the fact that distributed practice is beneficial in many situations where rehearsal is prevented. Rohrer (15) has shown that rehearsal may have no beneficial effect in the rote learning situation.

Many experiments that show the advantage of distributed practice have been attributable to work decrement rather than to truly learning factors. Especially in motor learning studies it has been shown that fatigue produces a lowering of performance which may be overcome by interpolated rest periods. Hull (7), in his concept of reactive inhibition, attempted to reconcile work decrement and learning principles by postulating the negative drive state which he attributed to reactive inhibition. Thus, the greater the effort involved in a response, the greater the amount of inhibition. Naturally, then, the growth of reactive inhibition will be greater as the interval between reactions decreases. Hull further states that reactive inhibition dissipates as a simple decay function of the amount of time allowed for rest.

Another attempted explanation which is derived from physiology, postulates some form of neural after-effect. Müller and Pilzecker (9), naming this effect perseveration, state that during a sufficient rest pause the memory trace will have time to be consolidated.

Cook (3) and Ericksen (4) working in the area of problem solving have found massed practice superior to distributed practice. Two recent studies (13, 14) in the area of concept formation failed to find any significant effect due to distribution of practice when the intertrial rest interval was 60 seconds or less.

Research in human compound trial-and-error learning reveals no systematic study that attempts to relate the effects of distribution of practice and complexity of the learning task. In a recent study by Brown and Archer (2), neither the main effect of distribution of practice nor the interaction between distribution and complexity was found to be statistically significant.

The primary purpose of the present empirical investigation was to study the main effects and interaction of task complexity (response defined) and distribution of practice. The apparatus used was the selective mathometer (11).

The secondary purpose of the present investigation was an attempt to introduce into an experimental human learning situation a completely automatic data collection system that would reduce the role of the experimenter to that of a trivial "overseer's" task. To accomplish this, technical modifications on existing equipment were engineered to specifications dictated by the preconceived research design, thus obviating Procrustean methods. Further, the complete analysis of data was computed by the I.B.M. Electronic Calculating Punch, Type 604, and I.B.M. Magnetic Drum Data-Processing Machine, Type 650, (See Appendix II) in order to demonstrate the feasibility and practicality of the use of such automatic equipment for relatively small specialized experimental studies. The apparatus is described in detail below.

In all mathometric studies (12) to date the acquisition curves, defined by the probability of first choice correct response (R_p), were plotted against trials (N). Each fitted curve originated at a hypothetical rationalized value (i) indicative of the initial chance solubility of the problem. All functions have been sigmoidal in form, having inflection points (Nip) positively related to the number of responses available (N_R) and acquisition rates (r) inversely related.

Noble (10) has suggested that trial-and-error learning of this type can be fitted to the following rational equation:

$$R_p = a(i)^{r^N} \qquad [1]$$

where R_p = the probability of correct first choice (dependent variable)

a = the asymptote or limit of R_p, taken as 1.00

i = the initial chance solubility, given by the reciprocal of the number of available independent and mutually exclusive responses

r = a rate parameter calculated by the least squares curve fitting method

N = the number of practice trials (independent variable)

The above equation [1] has been adopted from the Gompertz curve.[1] Farese (5) has demonstrated mathematically that this equation has the following properties:

1) positive slope when log i is negative and $r < 1$

---

[1]Brogden (1) in 1949 made use of Equation [1] to describe Vincentized curves of acquisition and extinction of an instrumental avoidance response in dogs. D. Lewis was responsible for the curve fitting.

2) negatively accelerated for positive values of $\underline{N}$ with a negative inflection point if $\frac{1}{e} < \underline{i} < \underline{a}$

3) sigmoidal in form for positive values of $\underline{N}$ and $\underline{R}_p$ if $0 < \underline{i} < \frac{1}{e}$

where e = base of Naperian logarithms (2.71828).

PROCEDURE

<u>Apparatus</u>. - The learning device, except for automatic programming and automatic I. B. M. data collection procedures developed by the author (6), was the selective Mathometer described in detail by Noble and Farese (11). The <u>S</u>'s panel consisted of a symmetrical semicircular array of 4 or 10 pushbutton reaction keys, among which <u>S</u> selected the correct responses. The stimuli were presented automatically at a 4.0-sec. rate by an electronically-rate-controlled slide projector with an exposure duration of 2.0-sec. and an inter-stimulus period of 2.0-sec. Reinforcement consisted of the automatic immediate onset of a green lamp with a 1.0-sec. duration following each correct response.

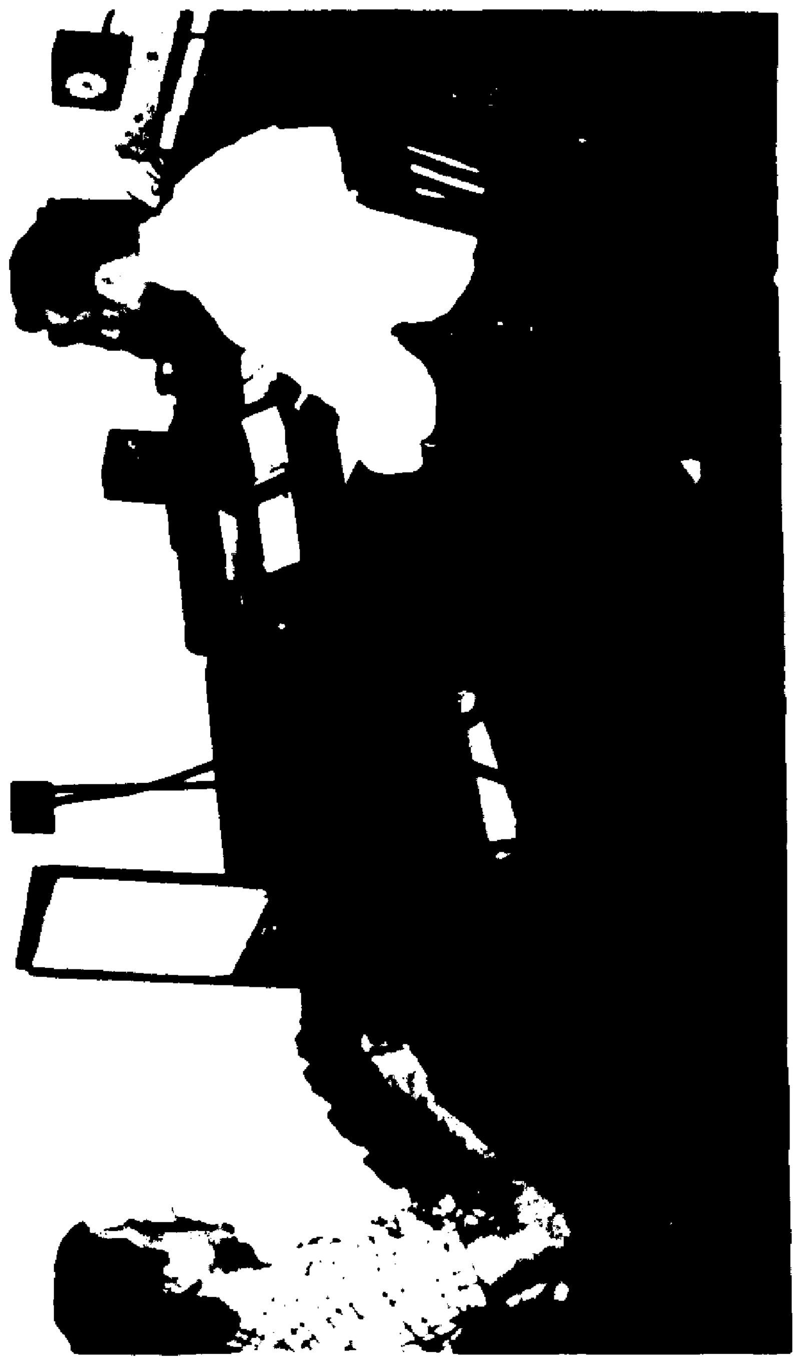
All responses, correct and incorrect, were collected on I. B. M. cards by the specially wired I. B. M. Type 024 Keypunch. In earlier studies on the selective mathometer, all responses were collected on an Esterline Angus 20 channel recorder. This procedure involved the laborious task of coding and encoding the "blips" on the Esterline Angus tape prior to counting and tallying the number of correct responses through <u>S</u>s by trials. This task plus summing across <u>S</u>s for each trial accounted for more than half the time involved in processing and analysing mathometric data.

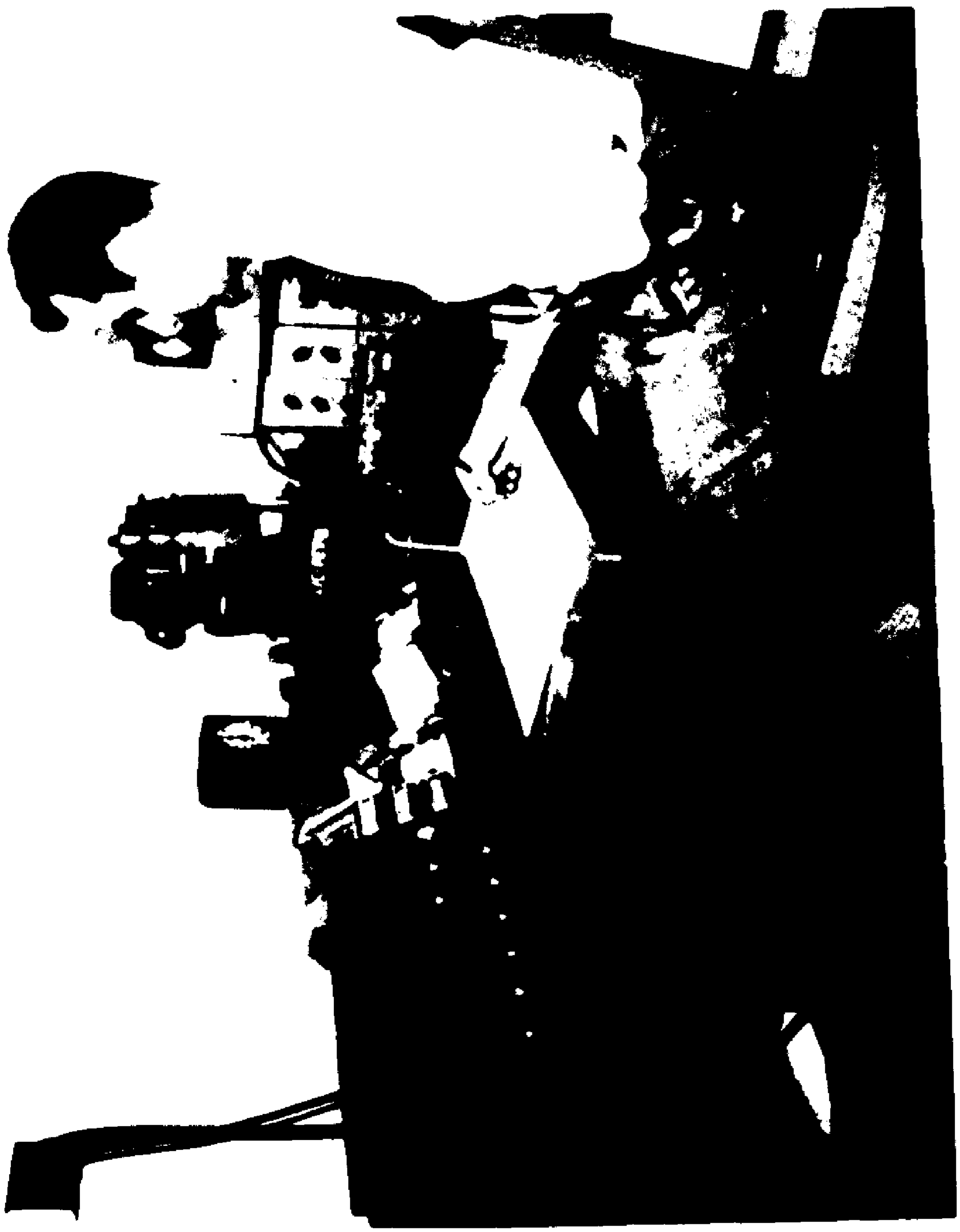
A completely automatic process of data collection and data analysis was envisioned and subsequently engineered for the present study. The method described in detail elsewhere (6) consisted essentially of the I. B. M. Type 024 Keypunch and accessory hardware for data collection, and the use of I. B. M. computers for data analysis. By wiring the Keypunch directly into the response circuits, Figure 1, the S actually punched a hole in an I. B. M. card when he made a response. This punch indicated the nominal response made (row of the card) and the trial on which it was executed (column field). Thus, when a S had completed 20 trials, a record of his responses (nominal and ordinal) were contained on a single I. B. M. card. This card also contained a treatment-combination code.

By use of the I. B. M. 604 using a special program of instructions the nominal responses made by each S were converted into the number of correct responses by trials. These conversions were used for the necessary analyses of variance computed by another program on the I. B. M. 604. The I. B. M. 604 machine time for conversions and analysis of variance was twelve hours. By previous methods using

Figure 1

The Selective Mathometer with the Automatic Programmer and the Data Collector.





the Esterline-Angus and a desk calculator, we would estimate that 640 hours would be required to accomplish the same analyses.

The curve fittings was accomplished on the I.B.M. 650 Memory Drum Data-Processing Machine by a specially written program of instructions. The ten curve fittings performed for this study were accomplished in one-third hour machine time. Compared with desk calculator procedures the same fittings would have taken approximately five man-weeks of calculations.

Task. - The S's task was four-choice selective learning, task length constant. Keys 2, 9, 7 and 4 were the correct responses in that order. Two levels of response complexity were utilized, i.e., $N_R = 4$ and $N_R = 10$ with a task length of four in each. Throughout the text the former will be designated C4 and the latter C10.

In C4 it was S's problem to select from among the four available keys (2, 4, 7, 9) the correct response at each choice point, in C10 from among the ten available keys (1, 2, 3, 4, 5, 6, 7, 8, 9, 10). Each S was instructed to use only the forefinger of his preferred hand for making choices. At each choice point only one choice was allowed (non-correction procedure) in an attempt to hold constant and minimal "work components." Late responding (choices made during inter-stimulus or inter-trial intervals), omitting a response during the stimulus duration, or making more than one response at a choice point was cause for rejecting a S. The complete instructions given to each S are shown in Appendix I.

Distribution of practice was here used in the conventional experimental sense, i.e., between-trial-distribution. Within trial distribution was held constant. Four levels of distribution were utilized, i. e., 2-, 4-, 10-, and 20-sec., hereafter designated D2, D4, D10, and D20 respectively.

To minimize intrinsic differential effects of the stimuli upon S's behavior, four paralogs were chosen which were low in familiarity and meaningfulness. The paralogs were GOKEM, TAROP, ZUMAP and LATUK. The stimuli in the order shown constituted a trial sequence. Each S was presented with 20 trials with the same response sequence, i. e.,

Stimulus		Response
S (GOKEM)	______________	R (Key #2)
S (TAROP)	______________	R (Key #9)
S (ZUMAP)	______________	R (Key #4)
S (LATUK)	______________	R (Key #7)

The stimulus sequence was invariant throughout the 20 trials.

Design. - There were 8 major groups corresponding to the combinations of task complexity (C4 or C10) and distribution of practice (D2, D4, D10 or D20) conditions. Thirty Ss served in each group, a total of 240 in the experiment. The dependent variable was correct responses. The order of testing followed a counterbalanced sequence through the 8 treatment combinations with 15 replications.

<u>Subjects</u>. - The <u>S</u>s were 240 Louisiana State University R.O.T.C. students assigned without bias to a treatment combination. Each <u>S</u> served individually for one session of ten minutes and was instructed to refrain from discussing the procedure with anyone who had yet to take part in the experiment.

RESULTS

The trial-by-trial performance of C4 and C10 under the four levels of distribution of practice conditions is plotted in Fig. 1 and Fig. 2 respectively. Fitting Equation [1] by a modified least squares method gives the following:

$$R_p = 0.250^{.760^{N}} \qquad [C4,\ D2] \qquad 95.0\%^{2} \qquad [2]$$

$$R_p = 0.250^{.785^{N}} \qquad [C4,\ D4] \qquad 97.3\% \qquad [3]$$

$$R_p = 0.250^{.764^{N}} \qquad [C4,\ D10] \qquad 96.1\% \qquad [4]$$

$$R_p = 0.250^{.710^{N}} \qquad \cancel{[C4,\ D20] \qquad 94.1\% \qquad [5]}$$

$$R_p = 0.100^{.895^{N}} \qquad [C10,\ D2] \qquad 99.4\% \qquad [6]$$

---

[2]This value indicates the percentage of determined variance accounted for by the least squares fit to the respective equation for each treatment combination.

$$R_p = 0.100^{.883^{N}} \qquad [C10,\ D4] \qquad 97.3\% \qquad [7]$$

$$R_p = 0.100^{.839^{N}} \qquad [C10,\ D10] \qquad 98.8\% \qquad [8]$$

$$R_p = 0.100^{.843^{N}} \qquad [C10,\ D20] \qquad 98.5\% \qquad [9]$$

In Fig. 3 the data are summed across the conditions of distribution of practice since this effect was not significant. The resulting fitted equations were:

$$R_p = 0.250^{.758^{N}} \qquad [C4] \qquad 97.0\% \qquad [10]$$

$$R_p = 0.100^{.867^{N}} \qquad [C10] \qquad 99.4\% \qquad [11]$$

A repeated measures analysis of variance was performed using the number of correct responses per trials as scores. This analysis for the first ten trials is summarized in Table 1. Two main effects were significant: Complexity (F = 196.14, df 1 and 232, $p < .01$) and Trials (F = 232.52, df 9 and 2088, $p < .01$). The main effect of Distribution was not significant. The significance of the Complexity term indicates that the probability of correct response was an inverse function of task complexity, i. e., more correct responses were made to the task with fewer possible responses available. The means were 27.63 and 14.03 correct responses for C4 and C10 respectively where the maximum number of correct responses for ten trials was 40 for each task with chance level at ten correct. The significant *F* ratio for trials indicated that performance increased as a function of practice.

The Trials x Complexity interaction was significant (F = 9.75, *df* 9 and 2088, $p < .01$) indicating that rate of increase in performance at progressive stages of practice was differentially affected by task complexity.

The rationale for the above analysis of variance for the first ten trials was that by trial ten C4 has approached an asymptote and in order to test the second order interaction using 20 trials might seriously violate the assumption of normally distributed variates. Further, it was not anticipated that the differences in rate of learning would be significantly dependent upon the effects of distribution and task complexity. However, it might be argued that by eliminating the last ten trials for C4 (obviously containing no significant difference between distribution conditions) we also eliminate the last ten trials for C10 where greatest differences seem to occur.

For this reason a repeated measures analysis of variance was performed for only the C10 condition for all 20 trials. This analysis is summarized in Table 2. The significant $\underline{F}$ ratio for Trials is of course expected ($F = 217.243$, $\underline{df}$ 19 and 2204, $\underline{p} < .01$). It is noted however that the main effect of Distribution ($\underline{F} = 4.724$, $\underline{df}$ 3 and 116, $\underline{p} < .01$) and Trials x Distribution interaction are significant ($\underline{F} = 1.730$, $\underline{df}$ 57 and 2204, $\underline{p} < .01$). The significance of the simple interaction indicates differences among the slopes of the curves shown in Fig. 2.

A third analysis of variance similar to Table 1 was computed for all 20 trials and is summarized in Table 3. It will be noted that again the main effects, namely, Complexity and Trials, are significant. The interaction between Trials x Complexity is also statistically significant. However, the interaction Trials x Complexity x Distribution is also significant ($\underline{F} = 1.786$, $\underline{df}$ 57 and 4408, $\underline{p} < .01$).

Tables 4 and 5 contain the trial by trial number of correct responses (R_+) and the probability of correct responses (R_p) for C4 and C10 for each level of distribution of practice, D2, D4, D10 and D20.

Figure 2

Probability of Correct Response as a Function of Trials for C4 for Each of the Four Levels of Distribution of Practice.

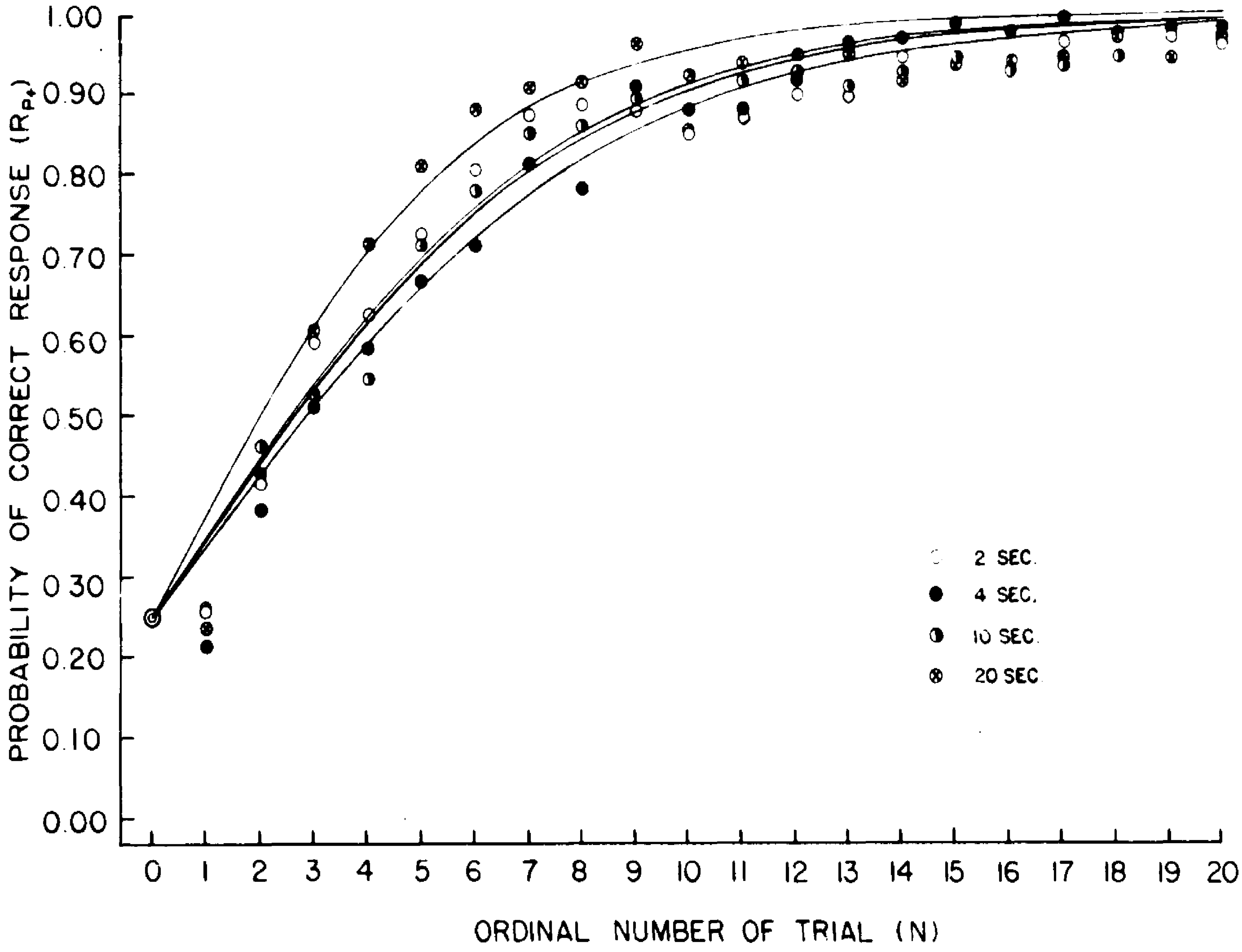
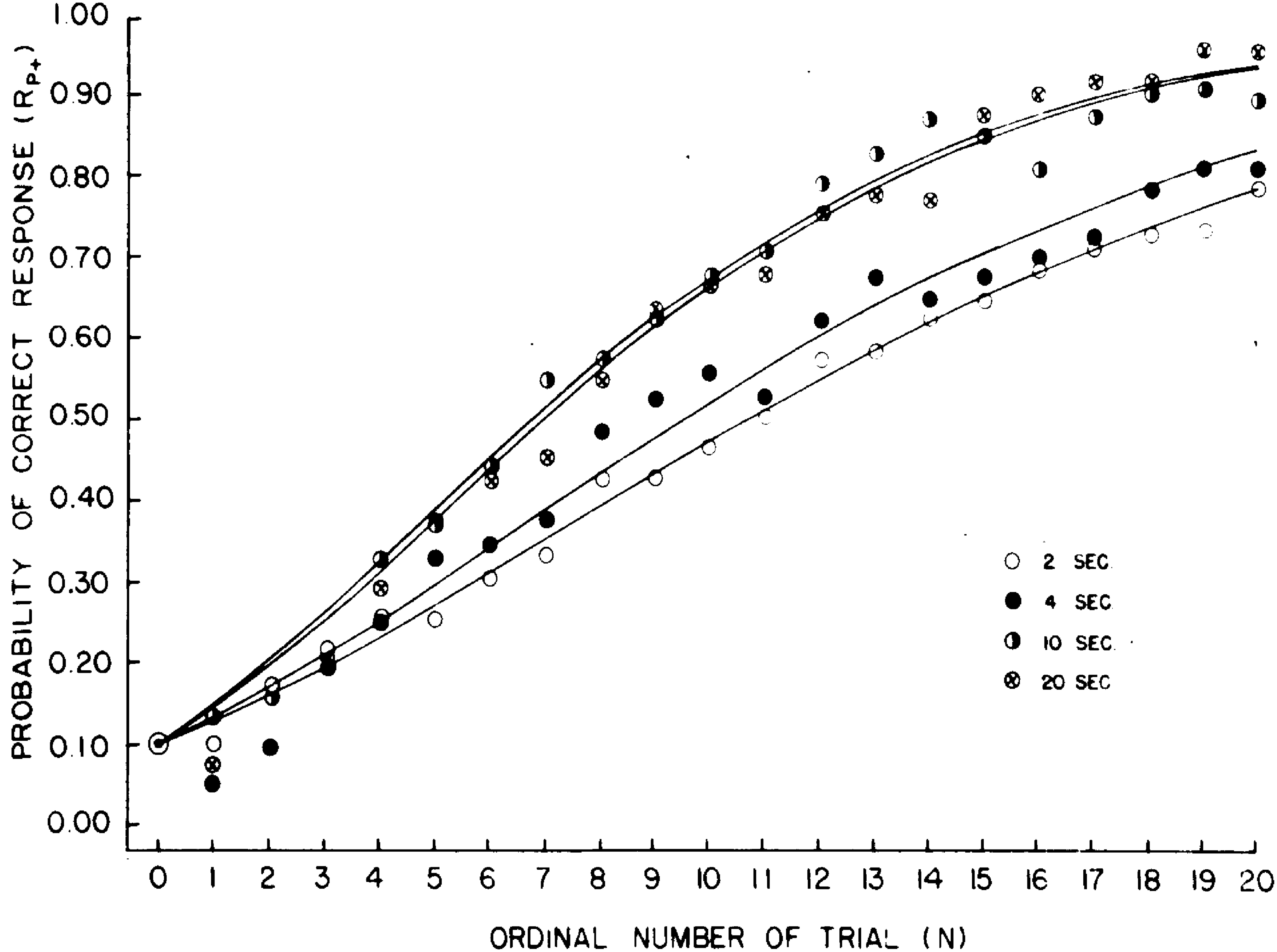

PROBABILITY OF CORRECT RESPONSE (R_{P+})
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
ORDINAL NUMBER OF TRIAL (N)
2 SEC.
4 SEC.
10 SEC.
20 SEC.

Figure 3

Probability of Correct Response as a Function of Trials for C10 for Each of the Four Levels of Distribution of Practice.



PROBABILITY OF CORRECT RESPONSE (R_{P+})
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
ORDINAL NUMBER OF TRIAL (N)
2 SEC
4 SEC
10 SEC
20 SEC

Figure 4

Probability of Correct Response as a Function of Trials for C4 and C10.

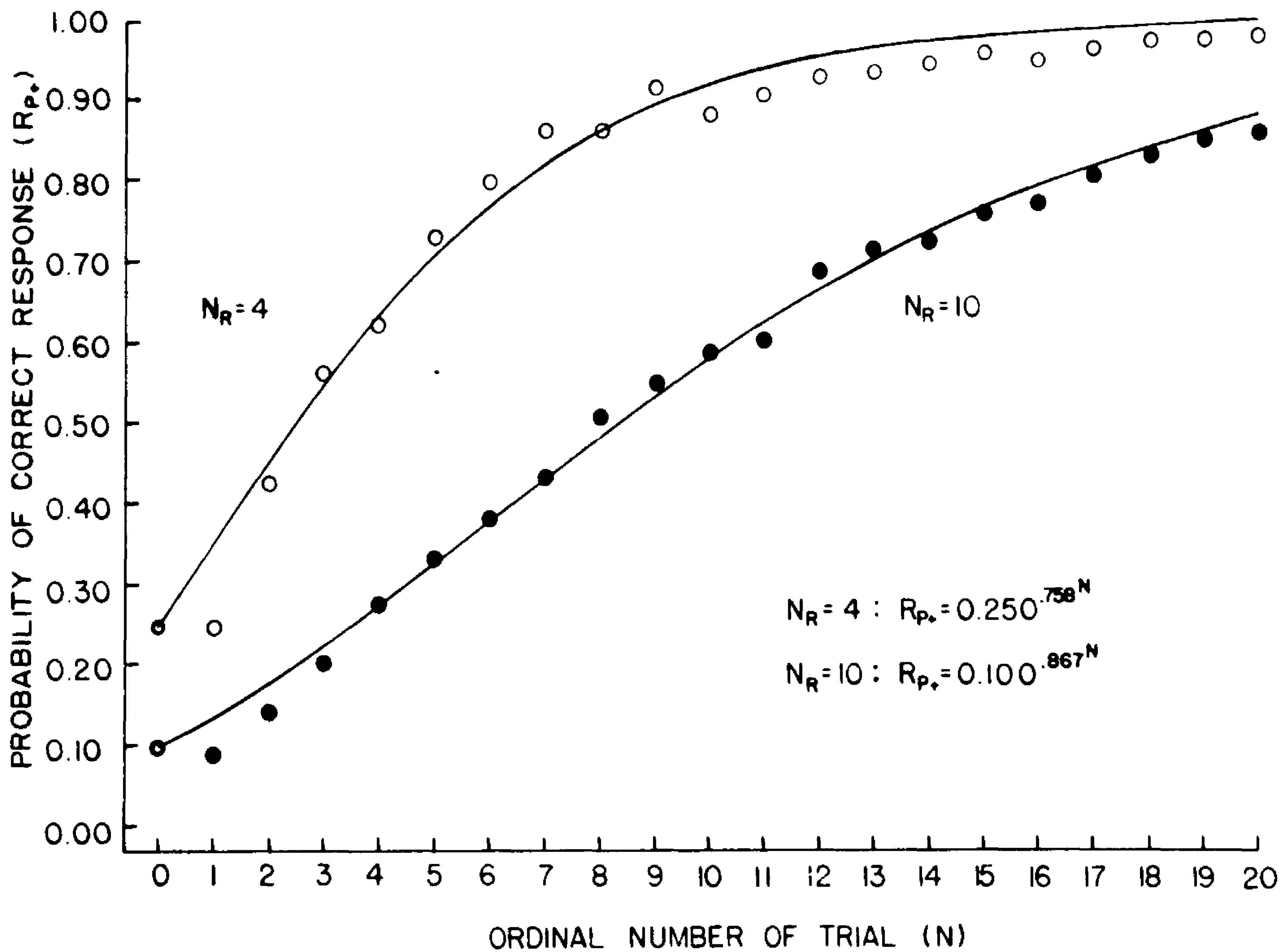

PROBABILITY OF CORRECT RESPONSE (R_{P+})
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
ORDINAL NUMBER OF TRIAL (N)
$N_R = 4$
$N_R = 10$
$N_R = 4 : R_{P+} = 0.250^{.758^N}$
$N_R = 10 : R_{P+} = 0.100^{.867^N}$

TABLE 1

Analysis of Variance of Correct Responses
Per Trial (1 to 10)

Sources	df	MS	F
Between - Subjects	(239)	(10.405)	
C	1	1111.121	196.14*
D	3	13.581	2.40
C x D	3	6.879	1.21
Error (b)	232	5.665	
Within - Subjects	(2160)	(1.271)	
T	9	147.419	232.52*
T x C	9	6.179	9.75*
T x D	27	.828	1.31
T x D x C	27	.623	.98
Error (w)	2088	.634	
Total	2399		

*$P < .01$ level

TABLE 2

Analysis of Variances of Number of Correct Responses for C10 for Trials 1 to 20

Sources	df	MS	F
Between - Subjects	(119)	(13.045)	
D	3	56.335	4.724*
Error (b)	116	11.926	
Within - Subjects	(2280)	(1.546)	
T	19	119.049	217.243*
T x D	57	0.948	1.730*
Error (w)	2204	0.548	
Total	2399		

*$P < .01$

TABLE 3

Analysis of Variance of Correct Responses
Per Trial (1 to 20)

Sources	df	MS	F
Between - Subjects	(239)	(15.786)	
C	1	1334.575	136.978*
D	3	35.946	3.689
C x D	3	23.326	2.394
Error (b)	232	9.743	
Within - Subjects	(4560)	(1.330)	
T	19	188.655	357.301*
T x C	19	10.435	19.763*
T x D	57	.607	1.150
T x D x C	57	.943	1.786*
Error (w)	4408	.528	
Total	4799		

*$P < .01$ level

TABLE 4

Frequency Distributions of Correct Responses (R_+) and Probability* of Correct Responses (R_p) for C4 for 20 Trials

	D2		D4		D10		D20		TOTAL	
Trial	R_+	R_p	R_+	R_p	R_+	R_p	R_+	R_p	R_+	R_p
1	31	258	26	217	32	267	29	242	118	245
2	50	417	46	383	56	467	52	433	204	425
3	71	592	62	517	64	533	73	608	270	563
4	75	625	70	583	66	550	86	717	297	619
5	87	725	80	667	86	717	98	817	351	731
6	97	808	86	717	94	783	106	883	383	798
7	105	875	98	817	103	858	109	908	415	865
8	107	891	94	783	104	867	110	917	415	865
9	106	883	110	917	108	900	116	967	440	917
10	103	858	106	883	103	858	111	925	423	881
11	105	875	106	883	111	925	113	942	435	906
12	108	900	111	925	112	933	114	950	445	927
13	108	900	116	967	109	908	115	958	448	933
14	114	950	117	975	112	933	111	925	454	946
15	114	950	119	992	114	950	113	942	460	958
16	112	933	118	983	112	933	113	942	455	948
17	116	967	120	1.000	113	942	114	950	463	965
18	117	975	118	983	114	950	117	975	466	971
19	117	975	118	983	118	983	114	950	467	973
20	116	967	118	983	117	975	117	975	468	975

* Decimal points have been omitted.

TABLE 5

Frequency Distributions of Correct Responses (R_+) and Probability* of Correct Responses (R_p) for C10 for 20 Trials

	D2		D4		D10		D20		TOTAL	
Trial	R_+	R_p	R_+	R_p	R_+	R_p	R_+	R_p	R_+	R_p
1	12	100	6	050	16	133	8	067	42	088
2	20	167	11	092	19	158	19	158	69	144
3	26	217	23	192	26	217	24	200	99	206
4	30	250	29	242	39	325	35	292	133	277
5	30	250	40	333	44	367	45	375	159	331
6	36	308	41	342	53	442	51	425	181	377
7	40	333	47	375	66	550	54	450	207	431
8	51	425	58	483	69	575	66	550	244	508
9	51	425	63	525	75	625	76	633	265	552
10	56	458	67	558	81	675	80	667	284	592
11	60	500	63	525	85	708	81	675	289	602
12	69	575	75	625	95	792	91	758	330	688
13	70	583	81	675	99	825	93	775	343	715
14	75	625	77	642	104	867	92	767	348	725
15	77	642	81	675	102	850	105	875	365	760
16	82	683	84	700	97	808	108	900	371	773
17	85	708	87	725	105	875	110	917	387	806
18	87	725	94	783	108	900	110	917	399	831
19	88	733	97	808	109	908	115	958	409	852
20	94	783	97	808	107	892	114	950	412	858

* Decimal points have been omitted.

DISCUSSION

The results of the experiment lend further support to the hypothesis that r is related to task factors and specifically that r can be experimentally manipulated by variations in the number of responses available. The effect of quantitatively controlling the difficulty of a task by varying distribution of practice is not as clearly defined as the effects caused by varying response availability. It appears that distribution early in practice does not differentially affect performance (Table 1), but as difficulty increases, the effects of distribution as practice continues become more pronounced (Table 2 and Table 3).

Distribution of practice as a main effect was not significant either early in practice (Trials 1-10) or in all 20 trials. Distribution as a main effect was significant however when C10 was analysed singularly. The primary purpose of this experiment was to test the effects of distribution of practice in a trial-and-error learning situation in which different levels of complexity were involved. In all analyses the interaction of task complexity and distribution of practice was not significant.

The effect of distribution of practice was also manifested in the Trials x Distribution interaction (Table 2) and the Trials x Distribution x Complexity interaction (Tables 1 and 3). The effect of distribution of practice early in learning was not apparent but for the last few trials better performance was associated with the longest rest interval. This is only noticeable or significant for C10. The significance of the second order interaction, Trials x Distribution x Complexity, implies that the differences observed between the levels of distribution of practice are dependent upon the stage of practice and the complexity of the task.

The generality of Equation [1] has been given added support by the present study. The coefficients of determination which encompass a greater range than previous studies (5, 10) are still relatively high. The percentage of variance accounted for ranges from 94.1% to 99.4%. Contrasted with response availability it does not appear that distribution of practice as an experimental variable will be as fruitful in rationalizing the r - parameter in Equation [1] .

A conservative evaluation of the apparatus and method of analysis used indicates that the use of automatic equipment for data collection along with commercial computers for data analysis is a great aid to psychological research and should be undertaken on a routine basis. The savings in time and money greatly outweigh the effort involved in learning these new methods and techniques. It seems safe to predict that the future of psychology will be greatly enhanced by the use of modern automatic equipment for data collection and by the use of digital computers for data analysis. The procedures used in this study indicate that previously performed major research projects will become comparatively simple studies (in terms of data analysis) when high speed computers and special equipment are incorporated into the design.

SUMMARY

The purposes of the present experiment were to study the main effects of distribution of practice and task complexity and the interaction of these two factors in a human trial-and-error learning situation and to demonstrate the practicality of the use of automatic equipment for data collection and the use of high speed computers for data analysis in a small psychological study.

The task of the S was to select from among an array of switches the correct response to a paralog projected on a screen. Each of the 240 Ss served individually, receiving 20 trials of four paralogs with the appropriated interpolated rest intervals. There were eight experiment groups corresponding to the combinations of distribution of practice (2-, 4-, 10-, or 20-sec. intertrial rests) and task complexity (4 and 10 responses available) conditions. Thirty Ss served in each group.

The major conclusions were: (a) varying the number of responses available was effective in varying task difficulty. (b) The main effect of distribution of practice was significant only for the more difficult task. (c) The interaction of

distribution of practice with task complexity was not significant. (d) The second order interaction of task complexity by distribution of practice by trials (1 to 20) was significant. (e) Added support was given to the use of a rationalized Gompertz growth curve for describing human trial-and-error learning. (f) A system of automatic equipment for data collection and digital computers for data analysis was demonstrated to be feasible and practical.

REFERENCES

1. Brogden, W. J. Acquisition and extinction of a conditioned avoidance response in dogs. _J. comp. physiol. Psychol._, 1949, 42, 296-302.

2. Brown, F. G., and Archer, E. J. Concept identification as a function of task complexity and distribution of practice. _J. exp. Psychol._, 1956, 52, 316-321.

3. Cook, T. W. Massed and distributed practice in puzzle solving. _Psychol. Rev._, 1934, 41, 330-355.

4. Ericksen, S. C. Variability in attack in massed and distributed practice. _J. exp. Psychol._, 1942, 31, 339-345.

5. Farese, F. J. Human mixed selective learning under a variant and an invariant stimulus sequence. Unpublished M.A. thesis. Louisiana State University, May 1955.

6. Farese, F. J. Applications of analog and digital computers in psychological research. Paper read at the I.B.M. Joint Applied Science Seminar, Houston, 1956.

7. Hull, C. L. _Principles of Behavior_. New York: Appleton-Century-Crofts, 1943.

8. McGeoch, J. A. and Irion, A. L. _The psychology of human learning._ New York: Longmans, Green and Co., 1952.

9. Müller, G. E., and Pilzecker, A. Experimentelle Beiträge zur Lehre vom Gedächtniss. _Z. Psychol._ 1900, Ergbd. 1.

10. Noble, C. E. The difficulty complexity relationship in compound trial-and-error learning. _Amer. Psychologist_, 1954, 9, 443. (Abstract).

11. Noble, C. E. and Farese, F. J. A simple apparatus for research in human selective learning. _J. Psychol._, 1955, 39, 475-484.

12. Noble, C. E. and Farese, F. J. Analysis of trial and error learning. _Annual Report,_ Research Grant NSF - G1284, Louisiana State University, 1956.

13. Oseas, L., and Underwood, B. J. Studies of distribution practice: V. Learning and retention of concepts. _J. exp. Psychol._, 1952, 43, 143-148.

14. Richardson, J., and Bergum, B. D. Distributed practice and rate learning in concept formation. _J. exp. Psychol._, 1954, 47, 442-446.

15. Rohrer, J. H. Factors influence the occurrence of reminiscence: attempted formal rehearsal during the interpolated period. _J. exp. Psychol._, 1949, 39, 484-491.

16. Sackett, R. S. The influence of symbolic rehearsal upon the retention of a maze habit. _J. gen. Psychol._, 1934, 10, 376-397.

17. Sackett, R. S. The relationship between amount of symbolic rehearsal and retention of a maze habit. _J. gen. Psychol._, 1935, 13, 113-128.

APPENDIX I

INSTRUCTIONS

"This is a test of problem-solving ability. With a slide projector I am going to show you - one at a time - a series of four words on this screen. As each of the four words appears on the screen, your job will be to find out which of these buttons (E points) is connected with it. Now you find this out by trying a button. Push it down quickly like this (E demonstrates). Use the forefinger of either your right or left hand, but use only one hand during the test. When you are not pushing a button keep your finger on this round metal plate.

"When a word appears on the screen, press a button. If that button is the correct one for the word that is on the screen, this green light will flash on. (E demonstrates.) Then after a moment, another word will appear on the screen. Make a choice for this one also. If you're wrong on this one, the green light will not come on, indicating that the button you pressed is not connected with the word on the screen.

"It is important that you make a choice every time a word appears, but only one choice. Do not press any buttons when there is nothing on the screen. Try to find the correct button for each word as quickly as possible.

"I will show a series of four words (then there will be a short rest period) then the same series again. You will complete the test when you have run through 20 series. Your goal is to turn on the green light as often as possible during the test. Any questions?

"We are now ready to begin the test. The slides will be shown in rapid order, so you must work fast to keep up. Ready? Here is the first word - make your first choice."

APPENDIX II

The I.B.M. Electronic Calculating Punch, Type 604, uses electronic methods for performing all basic types of calculations. Data are read from I.B.M. cards, the calculations are made by an electronic calculating unit in a fraction of a second, and the results are punched automatically in the cards. The desired program of instruction for any given problem is accomplished by wiring a panel which controls the sequence of arithmetic operation.

The I.B.M. Magnetic Drum Data-Processing Machine, Type 650, compared with the 604 is a larger and faster machine. However, the essential difference is that the 650 is a "stored-program" computer. Instead of wiring a panel to control the operations to be performed, the sequence of operations are punched on cards and then "read onto" a magnetic drum.

VITA

Francis J. Farese was born in Rochester, New York, August 12, 1928. He attended Maryknoll Apostolic College, University of Rochester and Trinity University, receiving from the latter in May 1951 a Bachelor of Science degree with a major in psychology. Entering the United States Air Force as a Private in June 1949, he rendered services as a psychological technician and clinical psychologist until his discharge with the rank of First Lieutenant in August 1953. He entered Graduate School at Louisiana State University September 1953. He received a Master of Arts degree in May 1955 with a major in psychology. Concurrent with his course work, he has been Clinical Assistant, Research Assistant and National Science Foundation Research Fellow. He is a member of Sigma Xi, American Psychological Association, Louisiana Psychological Association, Texas Psychological Association, Psi Chi, Pi Mu Epsilon and A.A.A.S. He is presently employed by International Business Machines Corporation as an Applied Science Representative.

EXAMINATION AND THESIS REPORT

Candidate: Francis John Farese

Major Field: Psychology

Title of Thesis: THE DIFFERENTIAL EFFECTS OF DISTRIBUTED PRACTICE IN COMPOUND TRIAL-AND-ERROR LEARNING

Approved:

Robert Thompson
Major Professor and Chairman

Richard J. Russell
Dean of the Graduate School

EXAMINING COMMITTEE:

I. A. Berg

Bernard M. Bass

Joseph S. Levinger

L. D. Shade

Date of Examination:

January 10, 1957